AN ANALYSIS OF DECISION MAKING IN WILDLAND FIREFIGHTING:

HOW SINGLE RESOURCE DOZER-PLOW FIREFIGHTERS DO IT

EXECUTIVE ANALYSIS OF FIRE SERVICE OPERATIONS
IN EMERGENCY MANAGEMENT

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Abstract

Wildland firefighters in Florida routinely respond to wildfires as single resource dozer-plow operators. During these incidents they are called on to make rapid tactical decisions under stress in order to suppress the fire. Currently, very little formal training is given to new recruits in the area of tactical decision making skills. The purpose of this research was to develop a strategy for improving tactical decision making training for dozer-plow wildland firefighters. Action research methodology was used to answer the following research questions:

1. What decision making models exist for single resources making rapid decisions under stressful situations?
2. What decision making model do single resource dozer-plow wildland firefighters use for making rapid tactical decisions on wildfires?
3. What training methods are currently available to improve the effectiveness of decision making on wildfires?
4. What training methods should be employed to increase the effectiveness of decision making on wildfires?

The first and third questions were answered by a review of the available literature. To answer the second research question, a cognitive task analysis methodology known as the Critical Decision Method (CDM) was utilized. Six dozer-plow firefighters were interviewed on a significant wildfire they had to make critical tactical decisions on. An analysis of the interviews showed that all firefighters almost exclusively used serial evaluation of decision points. These findings were consistent with the Recognition Primed Decision Model. A two part strategy for improving decision making training was recommended. Academy based training included simulator training, case studies, and critical thinking skills. Field based training included apprenticing, fire debriefing, and improvisation exercises.

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Introduction

Florida Division of Forestry (DOF) wildland firefighters routinely respond as single resource dozer-plow operators to wildfires. During these incidents they are called on to make rapid critical tactical decisions under very stressful situations in order to successfully and safely suppress the fire. Currently, very little formal training is given to new recruits in the area of tactical decision making skills.

The purpose of this research was to develop a strategy for improving wildfire decision making training for single resource dozer-plow wildland firefighters in the Florida Division of Forestry.

Action research methodology was used to answer the following research questions:

1. What decision making models exist for single resources making rapid decisions under stressful situations?
2. What decision making model do single resource dozer-plow wildland firefighters use for making rapid tactical decisions on wildfires?
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effectiveness of decision making on wildfires?

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Background and Significance

Much has been written on decision making and it's importance to the firefighter. Murtagh (1995) pointed out that fireground incident commanders (IC's) must have good decision making ability involving sound firefighting knowledge coupled with accurate fireground information. Murtagh described the decision making process as identifying the problem, establishing objectives, developing alternative solutions, selecting the alternative and implementing it. The worst case scenario must always be kept in mind and alternative actions considered. All decisions must be based on the basic tenets of firefighting; life safety, protection of exposures, confinement and extinguishment.

The initial attack IC has many decisions to make, starting with where to set up command and whether to assume command of other responding units or actively participate in controlling the incident. A key component of decision making

is effective communication that allows the tactical resources latitude to offer potential solutions to tactical problems (Smith, 1995).

Wildland firefighters are currently employed by the DOF with no requirement for previous training or experience in wildland firefighting. The DOF provides it's firefighter recruits with all the required training to become State certified as wildland firefighters in Florida. Recruits presently receive 57.5 hours of wildfire suppression training as part of their basic fire control training program (Florida Department of Agriculture and Consumer Services, 1995). This training is classroom based and does not teach decision making skills, employ simulations or utilize live burn training. In addition to this formal classroom training, new recruits receive on-the-job training in their districts suppressing wildfires under the direct supervision of their supervisor. Unfortunately, the wildfire occurrence trend in Florida has been steadily dropping (see figure 1) meaning there is less opportunity to get this 'real fire' experience in a timely manner.

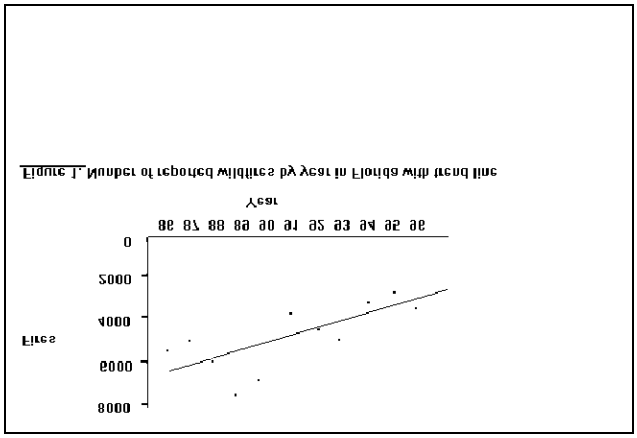


Figure 1. Number of reported wildfires by year in Florida with trend line

In spite of this training, the DOF continues to experience life threatening incidents on wildfires. From the period July, 1987 through June, 1997, the DOF experienced 53 burnovers, near misses, or fire damaged equipment incidents (G. Madden, personal communication, October 29, 1997), some with serious injuries. The DOF is very concerned with this significant number of incidents. Recent changes in the way initial attack tactics are being taught are a direct result of this concern.

The lack of training on decision making skills is not just a DOF problem. The findings of a National workshop designed to improve wildfire performance under stressful conditions revealed that most firefighters received little of no training on decision making skills. According to these findings, firefighters were asked to take risks and fight the

fire aggressively but also safely, however, the boundary between risk and safety is not always clear. Additionally, their was no training to teach firefighters when they were in over their heads (United State Department of Agriculture, Forest Service, 1995).

But it is also stressed that experience is sometimes the best teacher when it comes to making tactical decisions, especially during the heat of battle when decisions have to be make very quickly and the situation does not quite fit Standard Operating Procedures (SOP's). Huder (1995) noted that these experiences provide the foundation for the mental models needed to create a more complete situational awareness of complex incidents. Once firefighters acquire an understanding of the situation, they are more capable of making effective rapid decisions on the wildfire.

This research was initiated to determine how experienced, expert dozer-plow firefighters make tactical decisions on wildfires. By knowing what mental processes are being used to make these decisions, improved decision making training can be incorporated into firefighter development programs. Better tactical decision making will ultimately support the broader goal to improve the safety and quality of wildland fire suppression in Florida.

This applied research project fulfills the requirements for the Executive Analysis of Fire Service Operations in Emergency Management course of the National Fire Academy's Executive Fire Officer Program. This project is an application of Unit 2, Emergency Operations.

Literature Review

Decision Making in Emergencies

There are three features of emergency decision making that make it stand out from non emergency decision making; short time constraints, limited information, and decision load, i.e. a large number of decisions that are made in a short time (Cosgrove, 1996). Other factors include ill-structured problems, uncertain, dynamic environments, shifting goals and multiple players (Hart, 1995). Additionally, many decisions made during emergencies must necessarily deal with life threatening risks.

In his article on understanding life threatening risks, Keeny (1995) observed that risk decisions involve conflicting objectives. Looking at this from a emergency response standpoint, a conflict often develops between the objective to

stabilize the incident quickly and the need to keep firefighters free from injury or death. Evaluating risk also requires values. At some time during the decision making process, a value judgement is made based on what the decision maker determines is the 'best' alternative. It may not be recognized as such but it is not possible to make a decision without values and judgements. Thirdly, Keeny stated that evaluating risks involves both science and judgement. Decision making will be flawed if risks are evaluated only by science or values separately. Both are needed to make effective decisions.

Hart (1995) noted that attitudes, how one feels about something, affect decision making in high stress environments by framing and shaping the decisions used to make decisions. Attitudes help make sense out of the surroundings and build and maintain situational awareness. Attitudes can either positively of negatively affect the decision making process and are deeply interrelated with training and experience. Attitudes affect the emphasis of training and experience shapes attitudes.

In studies of decision making under risk, Bruce and Johnson (1996) found that performance was not adversely affected by an increase in the number of alternatives to

choose from. These researchers felt that the increased motivation which stemmed from having to make decisions that directly affected them may have prevented a deterioration of performance. Powerful environmental stimuli and a responsive decision maker may overcome the problems associated with complexity by implementing adaptive choice strategies.

In their work with how decision makers deal with uncertainty, Lipshitz and Strauss (1996) found that decision makers distinguished between three types of uncertainty; inadequate understanding, incomplete information, and undifferentiated alternatives. Subjects applied five strategies for coping with these uncertainties; reducing uncertainty, assumption based reasoning, weighing pros and cons of competing alternatives, suppressing uncertainty, and forestalling. Inadequate understanding was primarily managed by reducing uncertainty, incomplete information by assumption based reasoning, and conflict among alternatives by weighing pros and cons.

There has been much work done recently in the field of decision making on the wildland fires since the firefighter fatalities that occurred on Storm King Mountain during the South Canyon Fire in 1994. The South Canyon Fire Investigation (USDA Forest Service, 1994) concluded that despite the fact

that firefighters recognized that the situation on Storm King Mountain was dangerously worsening, they failed to modify their tactics, a fatal decision for many of the firefighters on that wildfire.

In analyzing the decisions that were made by firefighters on the South Canyon Fire, Weick (1995) pointed out that experience played a major role in the fatality incident, even though the firefighters were formally qualified for their assignments. He noted that the people making critical decisions were not necessarily the most experienced in making those decisions.

Atwood (1996) reinforced the experience factor in making wildfire decisions. Similar Type II crews working together on the Clearwater National Forest in 1994 made different decisions on disengaging from a fire based on the crew bosses' situational awareness of the hazards and perception of their crew's ability to perform under those hazardous conditions. Atwood pointed out that both crew bosses made the right decision, even though the actual risk was the same for both crews.

In his work with the United States Forest Service, Putnam (1995) speculated that the underlying cause of wildland firefighter deaths was the difficulty firefighters have to

make consistently make good decisions under stress. He pointed out that when under stress, humans use less and less criteria for making decisions, and that some of the criteria used may not be the most critical. Additionally, our thinking tends to underestimate hazards, particularly if the hazard is increasing rapidly. Therefore when small fires grow rapidly larger, decision making regresses to a reliance on fewer and fewer factors. Queen (1995) also noted when a situation becomes overwhelming and beyond the scope of everyday operations, firefighters tend to revert back to what they are comfortable with. Sometimes, firefighters are so conditioned to attack fires and rescue victims that they forget to change behaviors when the situation becomes hopeless.

Emergency Decision Making Models

Two types on emergency decision models were found in a review of the literature, decision support models and decision making models. These models take many forms ranging from simple decision trees to complex computer based systems. The following review will discuss each type separately.

Decision Support Models.

Cosgrove (1996) offered a relatively simple model for decision making during emergencies based on three problem characteristics; decision quality, the need for acceptance, and urgency. In this model each characteristic is divided into low and high groups and placed in a decision matrix. Cosgrove labelled the matrix the "emergency manager's decision cube"(see figure 2). The model recommends using normal decision making techniques to solve non-urgent problems but recommended four different actions, consult, act alone, delegate, and delegate with care, for dealing with urgent problems.

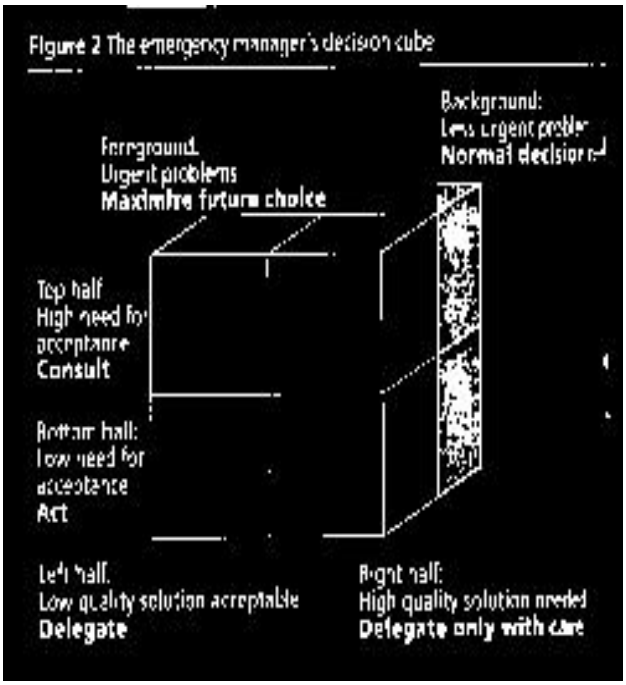
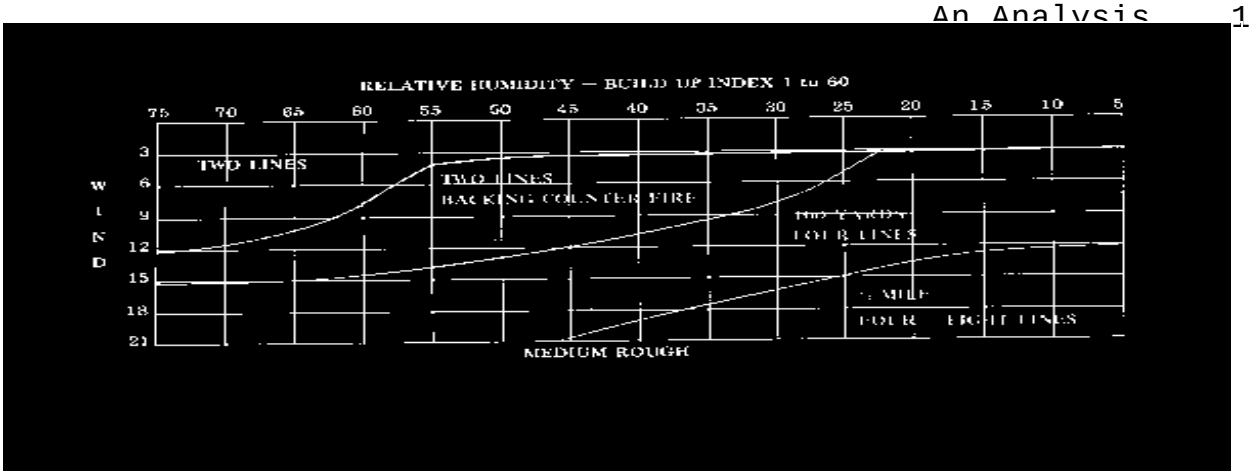


Figure 2. The emergency manager's decision cube.

The WILFRIED System is a spatial decision support system designed for wildland firefighting that uses a computer data base system, geographic information system, simulation models and user interface to help incident commanders make tactical decisions on wildfires (Guarie'ri and Wybo, 1995). This software system was designed to improve decision making and also to make decisions more consistent by using computer modelling to help the IC predict the fire behavior more accurately. It uses the Behave System developed by Rothermal and allows the user to quickly make what-if analyses on the fire behavior for critical fire weather situations.

The DOF (Florida Department of Agriculture and Consumer Services, 1983) developed a set of charts (see example in figure 3) for use by wildland firefighters using tractor plow suppression equipment in Florida fuels. These charts were developed by experienced Florida wildland firefighters for use in training novice firefighters in suppression tactics. They utilized the most important fire behavior factors in Florida, weather and fuels, to guide the user in the most appropriate tactic to use for that situation.

There are several structural triage decision support models published that are designed to assist firefighters with



making the decision to defend or abandon a home threatened by wildfire.The most widely recognized of these is the Wildland/Urban/Rural Structural Triage (WURST) Model (Cowardin, 1995). The WURST model is a decision tree type model that gives Figure 3. DOF tactical chart for medium palmetto-gallberry fuels.

the firefighter a quick guide for determining whether to defend or leave a threatened structure. It is built on a 25% rule for triaging structures where four defense elements; roof type, defensible space, terrain, and design, are each assigned 25%. A structure with 50% deficiency is considered a poor risk.

Decision Making Models.

Putman (1995) described a model for mental decision making where the process is basically additive. In this model,

several factors that are relevant to the decision are analyzed in order of their importance to the decision maker and a decision is made. Usually not more that seven factors are considered. However under stressful situations, the mind regresses to a simpler process where two or three factors will dominate the decision process. Putnam noted that people are seldom aware of the factors they are processing nor are they good at integrating all factors together. This model tends to underestimate hazards that increase exponentially, as happens many time on wildfires.

In their work with firefighting agencies in the 1980's, Klein, Calderwood, and Clinton-Cirocco (1985) found that Fire Ground Commanders rarely reported having considered more than one option when making rapid decisions on the fire ground. Their ability to make the proper decision depended on their skill in recognizing the situation and selecting a solution that was known to have worked in the past for that particular situation. The researchers labelled this model of decision making the Recognition-Primed Decision (RPD) Model. In a separate study, highly experienced wildland firefighting incident commanders were found to use recognitional decision making strategies during large wildland fires (Klein & Calderwood, 1996). This was more pronounced in areas where

they had their greatest expertise.

The RPD Model has three levels, the simple match, the diagnosis, and the evaluation (Klien, 1995). In the simple match level, the decision maker experiences a situation and mentally matches it to a typical situation which he already had experience. At the diagnosis level, expectancies are violated. The decision maker has to come up with a new scenario which fits the new evidence, but there is still no comparison of options. On the third level, the decision maker evaluates the chosen course of action by playing it through his/her head. If it worked in their head they would do it. If it didn't he/she would mentally modify it or discard and pick another course of action. Klein noted that the decision maker would not necessarily pick the best option but will pick the first one which he/she believes is possible and involved minimal risk. This model supports work performed at the Max Plank Institute (Bower, 1996) where researchers devised a model called "take the best". Using this model in deciding between two solutions to a problem, the subject deals with pertinent bits of information one at a time, moving from the best to the worst cues. A decision gets made based on the first cues that produce a workable answer.

Improving Decision Making in Emergencies

It has been pointed out previously that there is a genuine lack of decision making training for firefighters, however, many suggestions are being offered to remedy this problem.

As a result of an analysis of decision making at the South Canyon Fire, Putnam (1995) recommended mandatory training for, among other things, decision making under stress, and how to make organizations more stress resistant. Concerning decision making, Putnam recommended a task group of firefighters, trainers, psychologists and others be convened to develop actions to prevent decision making and organizational collapse under stress. A training program would then be developed to teach these skills to all personnel who must work in high stress environments.

In his analysis of the South Canyon Fire, Weick (1995) recommended several solutions to problems identified in the fire investigation. Among them, Weick advised to pay close attention to what firefighters overlearn since this is most likely what they will do when under pressure. For example, if firefighters have not practiced and overlearned shelter deployment or dropping firefighting tools and running from the fire, they will most likely not do those things when under

pressure. Weick stated that fire stories and case studies are crucial to extend a trainees' repertoire of experience, even if it second hand. He also stated that vidoetaping crew interaction during fires could prove to be a valuable gauge on how well the struggle for alertness is being waged.

Several recommendations for improving decision making were made at the Wildland Firefighters Human Factors Workshop (USDA Forest Service, 1995). Among these were:

* Study and formalize guidelines for engaging and disengaging from fire assignments.
* Develop decision making examples for wildland firefighters. Incorporate decision making into all training programs.
* Develop a situational awareness class and determine critical cues. Explore how to accelerate training of inexperienced firefighters.
* Develop leadership courses for all IC's. Determine the type of leadership needed on the wildfire and train accordingly.
* Develop 'hot seat' style fire simulators, possible utilizing computer modelling of fire behavior.
* Hire professional training companies to design training. Consider more hands-on interactive, field based training.

* Contract to study the best way to boost skills in a short time through on-the-job training.

The preliminary results of the Wildland Firefighter Safety Awareness Study (TriData Corporation, 1997) recommended developing a safer culture that encourages firefighters to think rather that just obey rules. Additionally, training was recommended to teach firefighters how to stay focused and deal with high information load under stress (critical thinking).

Keeny (1995) made four suggestions for making decisions involving risk. First, acknowledge the issues raised by the problem. Make sure the risk issues are openly acknowledged and appropriately addressed. Secondly, clarify the objectives of the problem. This is important for creating and appraising alternatives. Thirdly, identify the role of judgements about facts and values. Differences of opinion about what action to take are sometimes caused by different factual or value judgements. Clarify their relevance in each situation. Fourthly, communicate consistently with facts about risks. Effective communication allows everyone to better understand the problem as well as the risks.

In the aforementioned work with how decision makers cope with uncertainty, Lipshitz and Strauss (1996) proposed the RAWFS (Reduction, Assumption-based reasoning, Weighing pros

and cons, Suppressing uncertainty, and Hedging) heuristic, which describes strategies that decision makers apply to making decisions involving uncertainty. The heuristic assumes that the decision maker begins with an attempt to make sense of the situation, as is the case with the RPD model. The authors felt that this heuristic could be used in training to teach the strategies and tactics that are used by experienced decision makers.

As a result of their findings that fire ground commanders utilize the RPD model for decision making, Klein, Calderwood & Clinton-Cirocco (1985) suggested that training programs emphasize the perceptual learning needed to make fine discriminations. Additionally, experiences needed to be broadened to develop situational awareness skills and provide a bigger range of options for solving problems. Because agency SOP's are sometimes inadequate to address all life threatening situations Angione (1995) recommended that IC's create a set of 'personal policies', developed through study and experience, to extend SOP's by filling in the blanks created by unaddressed situations. In a later paper, Klein (1995) stated that decision training needs to teach firefighters to deal with ambiguous, confusing situations, with time stress and conflicting information. Training could teach firefighters

how to construct mental models and time horizons as well as how to operate under uncertain conditions and time pressure. Training methodologies would include specially designed training scenarios and after action reviews that provide cognitive feedback. Klein also recommended an apprenticing program whereby novices watch the experts do it. On-the-job training should be emphasized in addition to the formal training received.

Veillette (1997) recommended that the fire community take a lesson form the aviation community and provide human factors training as a way to improve decisions by wildland firefighters. Veillette grouped these factors into four categories called the SHEL Model; software, hardware, the environment, and liveware (humans). Software includes, rules and regulations, procedures, and instructions as well as computer software. Hardware is the equipment used for the task. The environment includes weather, fuels and topography as well as the organizational environment. Liveware is the differences each human exhibits physically and psychologically, our training, values, physical limitations and experiences. Equally important is the interface between the four groups.

Atwood (1996) believed that improvement must start with

the attitude of the supervisors and then spread up and down the organization. Communications is the key to making good decisions and supervisors must encourage communications with their subordinates even if that means questioning their decision. Atwood also recommended post fire critiques as a way to practice communicating strategy and tactics.

In analyzing Weick's work on the Mann Gulch Fire, Greenlee, Thomas and Gleason (1995) identified five organizational structures that could improve decision making. Improvisation, the process of creating solutions, could be part of training programs to help decision makers develop solutions to unexperienced problems. Virtual role systems means that all team members mentally take on all other team members roles in a crisis situation when communication or leadership is decaying. This allows the organization to function in spite of a breakdown in formal organizational structure. Thirdly, an attitude of wisdom is key to keeping the keeping open minds, keeping calm, and making sound judgements. Respectful interaction is the creation of an atmosphere that allows all affected team members to communicate effectively without fear. Finally, team pride reflected through, training, fitness, experience, and job satisfaction would help create a more cohesive unit that would

make the other four structures effective.

Conclusion

From a review of the literature it is evident that decision making during emergencies differs markedly from non-emergency situations. The factors inherent in decisions of this type cause decision makers to rely on a keen awareness of their situation as well as on past experiences to make an effective decision. The Recognition-Primed Decision Model accurately reflects the importance of these factors in making decisions in stressful environments. On this basis, I decided to use the methodology employed by Klein, Calderwood, & MacGregor, the Critical Decision Method, to determine if single resource dozer/plow firefighters use the RPD model to make tactical decisions on wildfires. A full description of this methodology is detailed in the Procedures section of this paper.

Procedures

A review of the literature was used to answer the first and third research questions. To answer the second research question, a cognitive task analysis methodology known as the Critical Decision Method (CDM) was selected. CDM (Klein, Calderwood, & MacGregor, 1989; Hoffman, Crandall, & Shadbolt, in press) is a method for modelling decisions made in a naturalistic environment. This environment is characterized by short decision time frames, changing conditions and incomplete information.

Generally, knowledge elicitation methods fall into three categories; routine task analysis, interviews, and contrived tasks (Hoffman, Shadbolt, Burton, & Klein, 1995). The CDM is "a retrospective interview strategy that applies a set of cognitive probes to actual non-routine incidents that required expert judgement or decision making" (Klein, Calderwood, & MacGregor, 1989, p. 464).

There are several features that distinguish this method from other knowledge elicitation methods. First, CDM focuses on non-routine incidents. This is done because these cases are usually the richest in usable data, especially if utilizing CDM to build or evaluate expert systems or identifying

training requirements. Secondly, interview questions are always specific to the incident. More specific and useful information is obtained this way. Thirdly, cognitive probes are not limited to objective questions. Subjects are also asked to reflect on the basis of their decisions. Finally, the probing is semi-structured. This helps keep the natural flow of the dialogue going while at the same time obtaining specific information.

A CDM session is organized around an account of a specific incident from the subject's own experience. Subjects should be selected based on their experience and expertise in the field the interviewer is eliciting knowledge on. The selection of subjects for this study was based on the definition of an expert proposed by Hoffman, Shadbolt, Burton & Klein (1995) which reads:

The distinguished or brilliant journeyman, highly regarded by peers, whose judgements and uncommonly accurate and reliable, whose performance shows consummate skill and economy of effort, and who can deal effectively with the rare or "tough" cases. Also, an expert is one who has special skills or knowledge derived from extensive experience with subdomians. (p. 132)

The interviewer must possess good communications skills and be familiar with the domain of knowledge that the subject has expertise in. Interviews should be tape recorded to verify notes taken during the interview. Subjects are encouraged to draw diagrams during the recounting to help them remember details of the incident. Each interview takes approximately two hours to complete.

The core procedure to conduct an interview is as follows:

1. Select an incident that would be considered non-routine, challenging, or where the decisions made may have differed from someone with less experience.
2. Obtain an unstructured incident account of the incident without interruption. Retell the story back to the subject to make sure that all detail was captured.
3. Construct an incident time line and establish the sequence andduration of each event. Include both verifiable events and thoughts and perceptions reported by the subject.
4. Identify the decision points. A decision point was defined as "a point in time where alternative courses of action could have been chosen, even if the alternative(s) had not actually been considered at the time" (Klein, Calderwood, & Clinton-Cirocco, 1985, p.3). Probe the decision point if the subject

agrees that other reasonable courses of action would be possible or the another subject might have chosen differently.

5. Probe the decision point. Use questions to gather the details of the use of cues, prior knowledge or experiences that influenced the decision. Also, gather information on specific goals and about options that were considered in making the decision. Probe the basis for selecting an option extensively.

A listing of the probe questions commonly used is shown inthe Appendix.

After the interview, the responses are coded for analysis. The needs of the specific research question define how the responses are coded. In this study the responses were coded to determine if the subjects, single resource dozer-plow firefighters, utilized the RPD model for making critical decisions on wildfires. The decision points were coded for whether concurrent or serial (RPD) evaluation was used. Using a concurrent evaluation, the decision maker considers several options at the same time. After options are evaluated, a selection is made and implemented. Using a serial evaluation, an option is generated, tested for feasibility, then either implemented or rejected. If it is rejected, a second option is

considered and so forth, until a suitable option is found.

Although not part of this study, a list of critical cues was generated for later analysis and possible incorporation into firefighter training.

The Study

Six expert dozer-plow firefighters employed by the Florida Division of Forestry were selected, one each from 6 of the 15 administrative districts of the State, based on recommendations from the District Manager of each District. The number of years experience ranged from 17 to 30 years with the average being 24 years. CDM interviews were conducted at the subjects' work stations during the period September 10-25, 1997.

Each subject was asked to recall a challenging wildfire incident they responded to as a single resource where they had to make complex decisions where less experienced firefighters would probably not have made the same choices. The interviews ranged from 75 to 110 minutes in length. The interviews were recorded and notes were taken. After each interview, the data was coded and the decision points analyzed.

Limitations

There are three potential limitations to using CDM. First, the interpersonal skills and domain knowledge of the interviewer must be sufficient to extract the necessary data to complete an accurate assessment. Secondly the memory limitations of the subjects will affect the amount and quality of data generated. Thirdly, a range of potential subject biases may distort the verbal data (Hoffman, Crandall, & Shadbolt, in press).

Results

The incidents recalled ranged from 3 to 350 acres in size and controlled times ranged from 45 minutes to 24 hours. One incident was brought under control by a single tractor, two by two tractors, two by three tractors and one by four tractors.

Thirty three significant decision points were recalled by the subjects. Each incident ranged from four to eight decision points with the average being 5.50 (see Table 1).

An analysis of the decision points revealed that 4 were evaluated concurrently and 29 were evaluated serially. No subject evaluated more that one decision point concurrently and two subjects made all evaluations serially.

Table 1

Coding of Decision Points by Subject

		Option Evaluation Method	
Subject	Decision Points	Concurrent	Serial
1	6	0	6
2	8	1	7
3	5	1	4
4	6	1	5
5	4	0	4
6	4	1	3
Totals	33	4	29

The subjects reported that they made 22 of the 33 decisions by considering no other options. The remaining 11 were made by considering only one other option. The subjects reported that 70% of the decisions were made based on prior experience with similar situations, 18% were made based on prior training and 12% on a combination of both.

A few tactical techniques came out of the interviews that were not taught but were learned from experience. An example

from one subject was a method of establishing a fireline along a hot flank that is efficient and relatively safe.

None of the subjects indicated that they consciously used the Division of Forestry tactical charts, however, there were several instances where the subject indicated that a decision was made based on training more than experience. Most of these decisions dealt with where to park the transport to insure it was safe from the fire or the decision to go to the head of the fire to start initial attack.

Discussion

The results of this study indicate that single resource dozer-plow operators use the Recognition-Primed Decision Model for making tactical decisions on the wildfire. This study paralleled very closely the findings of Klein's work with fire ground commanders (Klein, Calderwood, & Cirocco 1985) and his work with wildland firefighting incident commanders (Klein & Calderwood, 1996). As in those studies, the subjects relied heavily on recognitional decision making strategies. Additionally, the subjects infrequently co

The subjects on this study received their formal training in different ways. The Division of Forestry instituted a

formal fire control training program in the early 1970's. Originally consisting of 40 hours, it has now expanded to more that 400 hours. The most experienced subject of this study related that at the end of his formal 40 hour training session, the instructors required each firefighter to put out a fire with the dozer-plow under the observation of the instructors. This test insured that the firefighter could perform the basics of fire suppression. Later, the 'real fire' test was replaced by simulator training done in a classroom setting where the student's performance was critiqued by the instructors at the end of the simulation exercise. Around 1990, the simulator training was removed from the curriculum. Presently, firefighters are certified with no requirement for having fought a real or simulated fire. As it was with the US Forest Service (1995), this lack of decision making training under stress is major a concern.

It is obvious that experience plays a large part in making critical decisions. It's important to note that not all of the decisions made by the subjects were error free. Some of the decisions proved unworkable after they were executed requiring the subject to then reassess the situation and adjust his tactics until successful. They key is, however, that even though these fires were challenging and posed great

hazards to the firefighters, no injury or death occurred on these incidents. Just as Weick (1995) found in his analysis of the South Canyon Fire, had non-experienced firefighters been in these same situations, that might not have been the case. It is evident that expert firefighters excel at evaluating life threatening risk and balancing this with the need to control the incident (Keeny, 1995).

It was also evident that the subjects had a keen knowledge of the area where the fire occurred and a good feel for the kind of fire behavior to expect. They knew where the roads were, what fuel types would be encountered, where the natural and artificial breaks were and the capabilities of the dozer-plow. Most of this was obtained through experience.

During the interviews many of the subjects indicated that they immediately went to the head of the fire to start plowing. The subjects indicated that the decision to use this tactic was as a result of their training or a combination of training and experience. For several years the training provided to wildland firefighters in Florida was to stop the head first. All tactical charts were designed to stop the head. Recently, however, as a result of burnovers resulting in serious injury, more emphasis has been put on the need to establish a good anchor point before initiating suppression

action (I. Jolly, personal communication, October 10, 1997). Additional training emphasis is also being put on doing a thorough job in scouting the fire before starting suppression. This situational awareness training fits in well with the recognitional decision making strategies used by dozer-plow firefighters just as Huder (1995) recommended it's used for structural incident commanders.

The need to be creative was also evident with these subjects. As mentioned in the results, some of the subjects have developed their own tactics and rules of thumb for handling different situations. This trait is consistent with Angione's (1995) 'personal policies' to fill in the blanks created by unaddressed situations and Greenlee, Thomas and Gleason's (1995) improvisation organizational structure.

Recommendations

Based on the results of this study and a review of the available literature, a two part approach to decision making training is recommended for adoption by the DOF. The first part is to improve the way decision making is taught in the Academy. Decision making training should be expanded at the

Basic Fire Control Training Academy to include to following:

* Critical thinking skills. There are several critical thinking skill enhancement tools already available that could be adapted for use in the Academy.
* Reinstitute use of a simulator. Explore the use of the new computer assisted simulators utilizing CD ROM and laser disk technology.
* Utilize case studies as exercises in decision making. The case studies could come from CDM sessions like to those performed during this study to elicit knowledge from the experts.
* Teach to RAWFS heuristic for dealing with uncertainty. Confirm the validity of this heuristic within the wildland firefighting domain. If it proves valid, incorporate it into the curriculum.

The second part is to reinforce what has been taught at the Academy in the local district. As the local district level, implement the following strategies:

- Formalize an apprenticeship program that allows

experienced firefighters to pass along situational awareness and tactical decision making skills to inexperienced firefighters.

* Pair up experienced firefighters with novices on initial attack to wildfires.
* Critique (debrief) all significant fires, especially if the decisions made were not,'in the book'. Document critical ques that helped determine tactics.
* Practice critical thinking skills through structured improvisation exercises. This could be in group sessions or one on one as part of the apprenticing program.
* Reinforce the learning of critical wildfire safety objectives

(Overlearn the important stuff). Survival skills need to become automatic.

There are other strategies to improve decision making that don't fall into one of the above categories. These strategies, when more fully developed, can be incorporated into training programs in either the Academy or the field.

* Develop a list of critical ques for use in decision making training.
* Explore the value of the use of military Tactical Decision Games modified for the wildfire domain.

Implementation of these recommendations will require a commitment of time and resources beyond the scope of what the DOF can reasonably handle on it's own. It is recommended that partnerships be formed with other wildland firefighting agencies in the Southeast to develop the curriculum and software necessary to carry it out. The long term gains of safer more efficient fire fighting will pay big dividends for all involved.

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Appendix

Critical Decision Interview Probes

Probe Type	Probe Content
Cues	What were you seeing, hearing, smelling..?
Knowledge	What information did you use in making this decision, and how was it obtained?
Analogues	Were you reminded of any previous experience?
Goals	What were your specific goals at this time?
Options	What other courses of action were considered by or available to you?
Basis	How was this option selected/other options rejected? What rule was being followed?
Experience	What specific training or experience was necessary or helpful in making this decision?
Aiding	If the decision was not the best, what training, knowledge or information could have helped?
Time Pressure	How much time pressure was involved in making this decision?
Assess Situation	How would you summarize the situation?
Hypotheticals	If a key feature of the situation had been different, what difference would it have made in your decision?

Note. From "Critical Decision Method for Eliciting Knowledge," by G. A. Klein, R. Calderwood, and D. MacGregor, 1989, IEEE Transactions on Systems, Man, and Cybernetics, v.19, n. 3, p. 466. Adapted with permission of the author.